Article, undated

For a good many years past I have amused myself during my summer vacations in Nova Scotia with kite flying. There is a great facination in watching large structures floating in the air; structures of great weight as well as great size. One cannot help dreaming a little concerning the possibility of a man being carried up in one of these structure of an engine and propeller being installed, and then cutting loose from the anchor mooring that constitutes the machine as a kite and flying off under its own propulsive force.

In a large kite I see a flying machine at anchor, and in an aerodrome or flying machine I see a free kite.

In dealing with the Hargrave Box Kite a structural defect reveals itself the two cells of the box kite are rectangular in cross-section and hence are very easily distorted. This necessitates diagonal tie-wires which while they remedy the structural defect occasion increased head resistance in the kite.

By making the cells triangular in cross-section we remedy the structural defect without adding to the head resistance, and diminish the weight of the structure required for a given supporting surface. Placing the cell with its upper surface horizontal and the two other surfaces forming a V below it is obvious that the oblique surfaces are equivalent to the bottom and sides of a rectangular cell of which the horizontal top surface forms one side. It is obvious however that the material required to complete the rectangular cell would be greater in amount than material required to form 2 the V, so that the triangular cell weighs less than the rectangular cell of which it is the theoretical equivalent.

In kites formed of triangular cells however a structural weakness is developed in the longitudinal direction from fore to aft on account of the rectangular form which requires diagonal bracing in order to resist distortion. The diagonals however do not have the disadvantage of coming in the way of the wind, but the structural weakness can be remedied by giving the framework a triangular form in the longitudinal as well as in the transverse direction. Such a framework constitutes the skeleton form of a tetrahedron having four triangular faces, composed of six edges. In the regular tetrahedron the six edges are equal and such a frame gives the maximum of strength with the minimum of material. When two opposite faces are covered with silk or other materials suitable for kite surfaces we have a tetrahedral winged cell. In its flying position it resembles a pair of birds wings with the tips elevated and connected together by a cross-bar.

A number of years ago I constructed a gigantic Hargrave Box Kite each of the two cells being as large as a good sized room, but although small kites upon the same model had flown well in the air the gigantic structure would not support itself over 3 in quite a gentle breeze the gigantic structure would not support itself in the air excepting in a storm wind. This resulted of course from the fact that when we increase the dimensions of a structure the weight increases as the cube of the dimensions, whereas the supporting surfaces increase only as the square. If we double the dimensions the supporting surfaces will be four fold, but the weight will be eight fold. If we tripple the dimensions the supporting surfaces will be nine fold, but the weight will be twenty seven fold.

Mere increase of dimensions therefore will not give us a structure capable of bearing into the air a proportionally greater load. The weight of the structure itself increases in a greater proportion than the supporting surface, so that when you come to build a gigantic structure it will be too heavy to fly by itself far less carry up a heavy load. This has been one of the great difficulties in constructing a flying machine capable of carrying a man. Small models have been made which flew successfully, but when these models were duplicated upon a larger scale they failed to fly and had no surplus lifting power.

One great advantage of cells having triangular cross-sections is that small kites can be fastened together into a compound form without increasing the ratio of weight to supporting surface. On the contrary the ratio diminishes with the increased size of the compound structure. 4 For example, three triangular cell kites may be fastened together by their corners, and the compound structure so formed will weigh only three times as much as a single kite and have three times the supporting surface, so that if one of the component kites should be capable of supporting a small load in the air, the compound structure would support three times that load. The ratio of weight to surface is unchanged. But it is obvious that in this structure two adjoining sticks are employed where one would do, so that by the omission of duplicate sticks the weight of the compound structure will be less than three times the weight of a single kite without impairing the strength of the compound structure.

The advantage of the cellular construction increases with each increase of the dimensions, so that the compound structure is capable of carrying a larger proportional load.

This weight carrying capacity is still further increased when tetrahedral winged cells are used in place of sim triangular cells.

In triangular celled kites, as in the Hargrave Box Kite, the fore an aft cells are connected by empty framework which appears as dead load simply without any supporting surface attached. The tetrahedral winged cells however can be connected together by their corners without any empty framework between. Four such cells connected together at their corners form a perfectly rigid structure with an empty space between of octahedral form. Four of these four-celled kites connected 5 together at their corners form a rigid structure having sixteen cells with a large octahedral space in the center. Four-sixteen-celled kites connected together at their corners form an equally rigid structure of sixty-four cells with a still larger octahedral space in the center, which requires no empty framework to span it.

In these cases the compound structure itself has the form of a tetrahedron, and it is found in practice that the stability of such kites in the air increases with the number of cells composing them.

A sixty-four celled tetrahedral kite composed of cell having a side of 50 cm flys in a gentle wind and exerts so strong a pull that a man is unable to handle it without assistance. In my experiments with such kites we used a cleat of great strength on the general model of the cleats employed on steam boats for the attachment of ropes, and the flying lines were Manilla ropes of about a quarter of an inch in diameter.

From the difficulty of handling larger structures upon land

In I constructed a large kite composed of tetrahedral cells which, reasoning by analogy from the smaller structures formerly employed would have lifting power enough to carry up a man. It was thought well however to make the experiment over water rather than over land. The structure was therefore provided with three boat-shaped floats constructed 6 of tetrahedral cells covered with oilcloth to enable the structure to float upon the water. This was one of the earliest kites to receive a specific name. It was called the “Mabel of Beinn Bhreagh”. The “Mabel of Beinn Bhreagh” was launched upon Baddeck Bay in and was taken in tow by a steamboat. It was expected that when towed against the wind it would rise into the air and fly as a kite. The experiment was made without a man on board. On account of the great length of tow-line employed the kite failed to rise. The bows of the floats burried themselves in the water and the kite was upset, turning completely over upside down, but was supported by the floats so that it was recovered in a damaged condition. After repairs had been made a second experiment was made in spite of the fact that a rain storm came on soaking the surfaces of the winged cells. On this occasion the kite rose into the air with a tendency to fly on one side, so that the experiment had to be discontinued to save the kite from further injury. It was found that one of the floats was in a very leaky condition and the kite had carried up into the air a load of about sixty pounds of water irregularly distributed. These experiments revealed a structural defect that interfered with the manufacture of tetrahedral kites large enough to carry up a man. In order to afford sufficient lifting power for such a purpose the structure had to be made of enormous size, but on account of the large empty spaces in the kite without intervening framework to support them the structure became proportionally weaker as they were increased in size.

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Kites were then made in which the empty spaces were filled with empty frameworks of tetrahedral cells. This added to the structural strength but increased the head resistance and the lifting power of the kite, for the empty cells constituted mere dead load.

The experiment was then made to fill in the empty spaces with winged cells. In this form of construction the cells were all closely massed together and it was anticipated that the interior cells would be shielded by those in front of them and thus lose their efficiency. It was thought advisable however to ascertain by experiment whether kites composed of closely massed cells would fly, and to what extent a structure of this kind could be increased in size without losing its supporting power. The results were very surprising for the closely massed cells seem to fly as well as the open form of construction, while the strength of the whole structure was enormously superior. Another experiment was therefore made to construct a man-carrying kite. to which the name This was composed of 2 large tetrahedral kites connected together by a truss of strong cells, and it was named the “Siamese Twins”. This kite flew well without any man on board but it required a very strong wind to support it on account of the great weight of the tetrahedral truss that joined the kite together. This kite was then taken to pieces and another structure composed of light tetrahedral cells alone was made to test how far the massing of the cells could be carried without materially interfering with flying power. 8 All the light cells in the Laboratory, 1339 in number were closely massed together forming a structure having the form of a section of a tetrahedron — the upper half. This was completed at the time of a wedding on Beinn Bhreagh, and it was named in honor of the bride and bridegroom Mr. and Mrs. Frost it was named the “Frost-King”.

It was found that this kite composed of 1339 closely massed winged cells flew well in a breeze that did not create white-caps on Baddeck Bay, and the lifting power was so great as to support a man in the air hanging on to the flying-rope. This had not been expected. The man simply tested the supporting power by trying to hang on to the rope when a slight increa increase in the wind caused the rope to straighten and the man was carried up to a height of over 30 feet hanging on to the rope. The experiment amply demonstrated the strength and lifting power of structure composed of closely massed cells and it was determined to make a still larger structure and send a man up into it.

Before doing so however it was thought well to make numerous experiments to improve the method of making tetrahedral cells. Up to this point the cells had been composed of sticks which were tied together by hand. The process was laborious and expensive. With the assistance of Mr. Hector P. McNeil we were enabled to make corner pieces stamped out of tin which materially diminished the labor involved in manufacturing cells and diminished the cost.